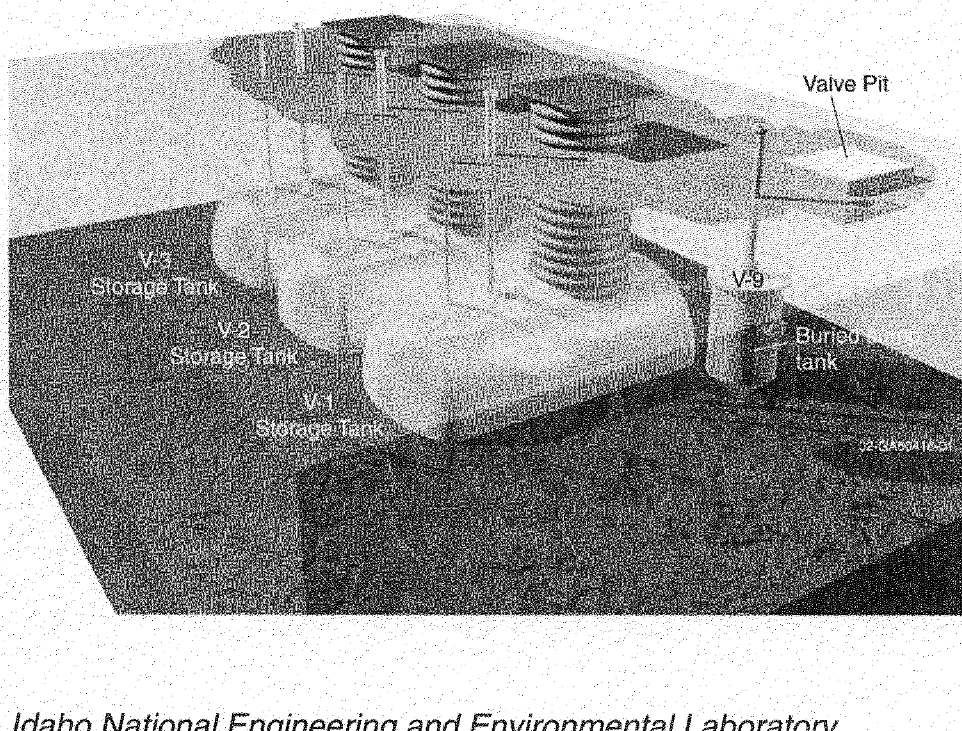
INEEL/EXT-02-01310

Pre-Conceptual Designs of Various Alternatives for the V-Tanks, TSF-09/18 at Waste Area Group 1 Operable Unit 1-10

Revision 0
November 2002



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Idaho National Engineering and Environmental Laboratory

Idaho Falls, Idaho 83415

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U.S. Department of Energy
Assistant Secretary for Environmental Management
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Pre-Conceptual Designs of Various Alternatives for the V-Tanks, TSF-09/18 at Waste Area Group 1 Operable Unit 1-10

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Approved by

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25 November 2002
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11/25/02
Date

ABSTRACT

The purpose of this report is to provide the preconceptual designs generated as alternatives for remedial action of the V-tanks at Test Area North at the Idaho National Engineering and Environmental Laboratory. The current remedy identified in the Record of Decision for the V-tanks cannot be executed since the identified off-site treatment facility is no longer available. Therefore, the technology screening process was repeated and a focused feasibility study, as documented in this report, was conducted in accordance with an approved Technology Evaluation Scope of Work (DOE-ID 2002d).

Three primary treatment technologies were identified and include: 1) vitrification, 2) thermal desorption, and 3) chemical oxidation followed by stabilization. Variations within these technologies were identified, resulting in seven specific remedial alternatives as listed below:

- In situ vitrification
- Ex situ vitrification
- Thermal desorption with on and off-site treatment and disposal of waste streams
- Thermal desorption with on-site treatment and disposal of waste streams
- Thermal desorption with off-site treatment and disposal of waste streams
- In situ chemical oxidation and stabilization
- Ex situ chemical oxidation and stabilization.

A primary focus of the preconceptual design effort was to address the threshold criteria identified within the Comprehensive Environmental Recovery, Compensation and Liability Act (CERCLA), which are protection of human health and the environment and compliance with applicable or relevant and appropriate requirements (ARARs). All alternatives were determined to meet these criteria. In addition, the design effort was to provide sufficient detail to allow a comparative analysis of the alternatives against the remaining CERCLA criteria. To accomplish this, the designs focused on generating a process flow diagram, equipment list, mass balance and waste disposition pathways. This information was ultimately used by the regulating agencies to select a preferred alternative as identified in the Technology Evaluation Report (DOE-ID 2002a).

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TABLES

ACRONYMS

AA	atomic absorption
AEA	American Electronics Association
AOC	area of concern
ARAR	applicable or relevant and appropriate requirements
ATG	Allied Technology Group
BEHP	bis (2-ethylhexyl) phthalate
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFT	contaminant for treatment
COLIWASA	composite liquid waste sampler
CO/S	chemical oxidation/stabilization
D&D	decontamination and decommissioning
DOE	Department of Energy
DOP	dioctyl phthalate
DRE	destruction and removal efficiency
EPA	Environmental Protection Act
ES-CO/S	ex situ chemical oxidation followed by stabilization
ESV	ex situ vitrification
GAC	granular activated carbon
GLRV	glass lined reaction vessel
HEPA	high efficiency particulate air
ICDF	INTEC CERCLA Disposal Facility
ICV	in-container vitrification
INEEL	Idaho National Engineering and Environmental Laboratory

INTEC	Idaho Nuclear Technology and Engineering Center
IS-CO/S	in situ chemical oxidation followed by stabilization
ISV	in situ vitrification
LDR	land-disposal restriction
MACT	maximum achievable control technology
ME	mist eliminator
MEE	melt ejection event
MPI	multi-point grout injection
NESHAP	National Emission Standards for Hazardous Air Pollutants
nonMACT	nonmaximum achievable control technology
NTS	Nevada Test Site
OU	operable unit
PFD	process flow diagram
PPE	personal protective equipment
RCRA	Resource Conservation and Recovery Act
RMERC	roasting or retorting mercury
ROD	Record of Decision
SGAC	sulfur impregnated GAC
SVOC	semivolatile organic compound
TAN	Test Area North
TCLP	toxicity characteristic leaching procedure
TD	thermal desorption
TD on/off-Site	on-Site liquid and sludge treatment and containerization, off-Site treatment of secondary waste (off-gas residuals), and on-Site disposal of residuals

TD on-Site	on-Site liquid and sludge treatment, containerization, and treatment of secondary waste (off-gas residuals), with on-Site disposal of residuals
TD off-Site	on-Site liquid and sludge treatment and containerization, with off-Site treatment of secondary waste (off-gas residuals), interim storage, and disposal of residuals
TFR	technical and functional requirement
TRU	transuranic
TS	treatment standard
TSCA	Toxic Substances Control Act
TSDF	Treatment, Storage, and Disposal Facility
TSF	Technical Support Facility
UCL	upper confidence limit
UHC	underlying hazardous constituent
VIT	vitrification
VOC	volatile organic compound
WAC	Waste Acceptance Criteria
WIPP	Waste Isolation Pilot Plant

1. INTRODUCTION

Four underground stainless steel tanks (collectively known as the "V-tanks") were installed at Test Area North (TAN) in the early 1950s as part of the system designed to collect and treat radioactive liquid effluents from TAN operations. The V-tanks are underground stainless steel tanks, and they are part of Operable Unit (OU) 1-10. These four tanks are identified as Tanks V-1, V-2, V-3, and V-9, with V-1, V-2, and V-3 identical in shape and size and V-9 having a unique, smaller shape (see Figure 1). Tanks V-1, V-2, and V-3 were used for storage, while Tank V-9 was used as a primary separation tank to separate sediment and sludge from the liquid waste before transferring that waste to V-1, V-2, or V-3.

Each of the V-tanks currently contains a liquid and sludge layer, and all of the V-tanks lack secondary containment. The tops of Tanks V-1, V-2, and V-3 are approximately 10 feet below grade (see Figure 2), while the top of Tank V-9 is 7 feet below grade (see Figure 3). Table 1 summarizes the tanks' capacities and current contents. The remedial action discussed in this report addresses the contents of these four tanks.

This report presents three alternative technologies:

- Vitrification (VIT)
  - In situ vitrification (ISV)
  - Ex situ vitrification (ESV)
- Thermal desorption (TD)
  - On-Site desorption with off-Site treatment of off-gas residuals (TD on/off Site)
  - On-Site desorption with direct treatment of off-gas residuals (TD on-Site)
  - On-Site desorption with off-Site disposal of concentrated solids and off-Site treatment of off-gas residuals (TD off-Site)
- Chemical oxidation/stabilization (CO/S)
  - In situ chemical oxidation followed by stabilization (IS-CO/S)
  - Ex situ chemical oxidation followed by stabilization (ES-CO/S)

Remediation of these tanks is an essential element of the Idaho National Engineering and Environmental Laboratory (INEEL) Accelerated Cleanup Project to cleanup and close Department of Energy (DOE) Environmental Management facilities at the INEEL. The current Record of Decision (ROD) alternative (DOE-ID 1999a) must be re-evaluated. No off-Site facilities capable of treating the tank contents, as required by the designated remedy in the ROD, are currently available or likely to become available.

This report provides preconceptual designs and technical data for the three main technologies selected for evaluation as possible replacements for the current ROD alternative (DOE-ID 1999a) for V-Tank remedial action. The three technologies to be evaluated, and the overall evaluation process, were identified in the Technology Evaluation Scope of Work for the V-Tanks (DOE-ID 2002d).

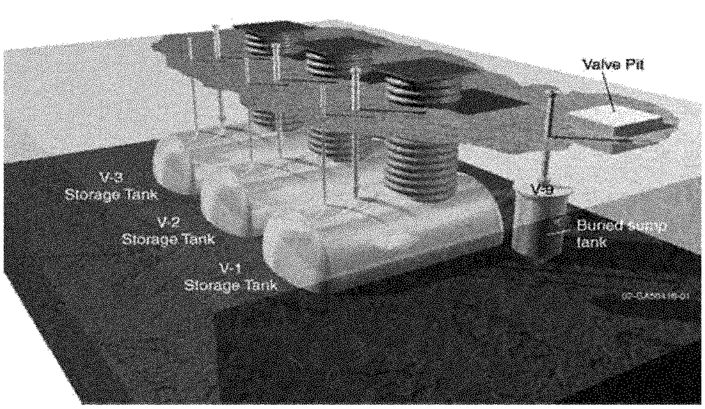

Figure 1. V-tank configuration.

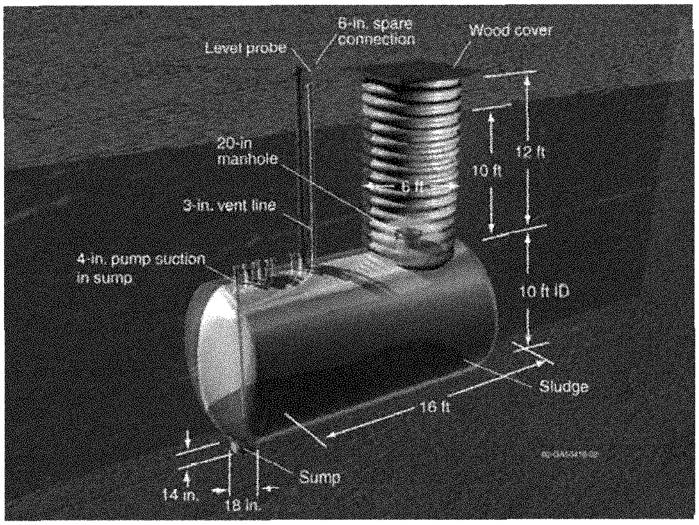

Figure 2. Tanks V-1, V-2, and V-3.

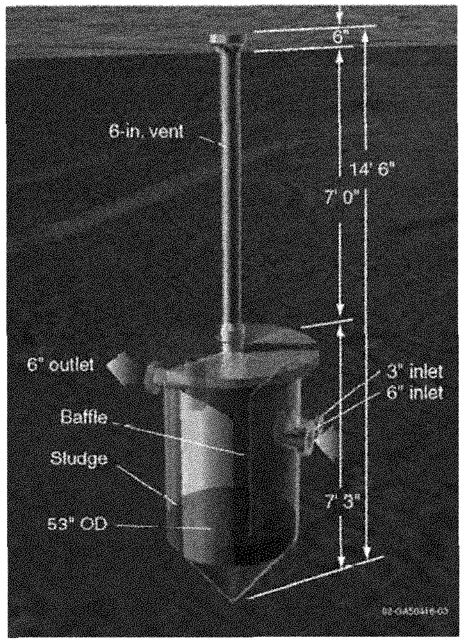

Figure 3. Tank V-9.

Table 1. V-tank volume in gallons.

Tank	Capacity	Liquid Volume	Sludge Volume	Total Volume
V-1	10,000	1,164	520	1,684
V-2	10,000	1,138	458	1,596
V-3	10,000	7,661	652	8,313
V-9	400	70	250	320
Total	30,400	10,033	1,880	11,913

The alternate V-tank waste treatment technologies discussed in this report are: vitrification (VIT), thermal desorption (TD), and chemical oxidation/stabilization (CO/S). For each technology alternative, there is a technology overview; a list of key assumptions; preliminary technical functional and requirements (TFRs); a discussion of major components and process steps; process flow diagrams; summary mass balances, estimates of waste form volumes; and a discussion of waste disposition pathways. Cost estimates and comparative analyses of the alternatives against the criteria in the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) will be included the Technology Evaluation Report (DOE/ID-2002a). The Technology Evaluation Report will use all available information to establish the treatment alternative ultimately used to accelerate tank cleanup and closure. A ROD amendment will be required to enable this treatment alternative.

The previous remedial action plan addressed in the V-Tanks Remedial Design/Remedial Action Work Plan (DOE/ID 2001a) included treating each tank contents phase, liquid and sludge, separately. The selected action included removing, de-watering, and shipping the tank content sludge phase to Allied Technology Group (ATG), an out-of-state commercial treatment facility, for treatment. However, the identified out-of-state treatment facility is no longer available; therefore, the alternatives discussed in this report were chosen for evaluation because of their ability to treat a combination of sludge and liquid. The specific alternatives chosen and their variations are:

- Vitrification (VIT)
  - In situ vitrification (ISV)
  - Ex situ vitrification (ESV)
- Thermal desorption (TD)
  - On-Site desorption with off-Site treatment of off-gas residuals (TD on/off-Site)
  - On-Site desorption with direct treatment of off-gas residuals (TD on-Site)
  - On-Site desorption with off-Site disposal of concentrated solids and off-Site treatment of off-gas residuals (TD off-Site)
- Chemical oxidation/stabilization (CO/S)
  - In situ chemical oxidation followed by stabilization (IS-CO/S)
  - Ex situ chemical oxidation followed by stabilization (ES-CO/S).

To analyze the chosen alternatives, the INEEL, in conjunction with the regulating agencies, developed a list of contaminants for treatment (CFTs). These CFTs are based on disposal requirements per Resource Conservation and Recovery Act (RCRA) constituents and the Waste Acceptance Criteria (WAC) of the selected disposal facility(ies). The list of CFTs is presented in Table 2. A detailed discussion of these CFTs is provided in Appendix A.

Table 2. V-tank contaminants for treatment.

V-tank Contaminants for Treatment	
Inorganics	**VOCs**
Antimony (Sb)	Tetrachloroethylene (PCE)
Arsenic (As)	1, 1, 1—Trichloroethane (TCA)
Barium (Ba)	Trichloroethylene (TCE)
Beryllium (Be)	
Cadmium (Cd)	**Semi-Volatile Organic Contaminants (SVOCs)**
Chlorides (Cl)	bis (2-ethylhexyl) phthalate (BEHP)
Chromium (Cr)	Polychlorinated Biphenyls (PCBs)
Lead (Pb)	
Mercury (Hg)	**Radionuclides**
Nickel (Ni)	Cesium (Cs-137)
Silver (Ag)	Strontium (Sr-90)
	Transuranics (TRU)[a]

a. Includes Plutonium (Pu-238. Pu-239/240). Americium (Am-241). Curium (Cm-243/244). Neptunium (Np-237).

The following sections use the above list, in conjunction with other key processing parameters, to establish material mass balances from each of the alternatives. Each process flow diagram includes pre-processing steps (soil addition, liquid decant, etc.) to enhance the design. Data are provided in Appendix B for sample calculations at the 95% upper confidence level, and detailed materials balance sheets for all alternatives are provided in Appendix C. The V-tank data provided in the body of the report is based on average concentrations (calculated using a weighted average based on tank mass), while the data listed in the mass balance sheets (see Appendix C) uses 95% UCL for selected CFTs.

2. OVERARCHING ASSUMPTIONS AND REQU REMENTS

2.1 Assumptions for Remediation Goals

Characterization assumptions for the V-tank waste contents are:

- Waste in the V-tanks has undergone previous RCRA characterization. The entire V-tanks content is characterized as RCRA code F001, due to the spent halogenated solvent (TCE) used in degreasing. Other organics that are listed as underlying hazardous constituents under F001, such as PCE and TCA, will require treatment per the F001 standard.
- Additional characterization activities will be undertaken prior to treatment to clarify the need to add additional characteristic waste codes and to confirm final LDR treatment requirements.
- All secondary waste from each treatment alternative will be characterized as F001 due to the "derived-from" rule.
- Only secondary wastes (F001) that meet land disposal restrictions (LDRs) are considered for disposal on-Site at the INTEC CERCLA Disposal Facility (ICDF).
- Secondary wastes (F001) that do not meet LDR and that cannot be practically treated on-Site, per the treatment alternative flow sheet, will be sent off-Site for treatment.

The V-tank composition, assumed as feed to the treatment alternatives evaluated, consists of the species shown in Table 3:

Table 3. Major contaminants for treatment (concentration mg/kg or nCi/g).

Component	V-1	V-2	V-3	V-9	Average[a]
Inorganics					
Aluminum (Al)	5.27E+02	1.12E+03	9.23E+02	2.69E+03	9.67E+02
Antimony (Sb)	5.13E+00	5.35E+00	3.43E+00	1.15E+01	4.90E+00
Arsenic (As)	3.00E+00	3.45E+00	3.08E+00	3.05E+00	3.15E+00
Barium (Ba)	4.33E+01	3.80E+01	4.13E+01	2.99E+02	5.62E+01
Beryllium (Be)	8.31E+00	4.24E+00	5.33E+00	2.02E+01	6.75E+00
Cadmium (Cd)	2.02E+01	2.27E+01	1.82E+01	2.18E+01	2.02E+01
Calcium (Ca)	1.78E+03	2.24E+03	2.34E+03	6.75E+03	2.42E+03
Chlorides (Cl)[b]	2.08E+02	1.02E+02	6.90E+01	3.97E+02	1.36E+02
Chromium (Cr)	5.26E+02	1.12E+03	9.23E+01	1.88E+03	5.96E+02
Iron (Fe)	2.63E+03	5.58E+03	5.77E+03	1.46E+04	5.35E+03
Lead (Pb)	2.55E+02	3.03E+02	2.60E+02	4.54E+02	2.82E+02
Magnesium (Mg)	2.64E+03	2.24E+03	3.47E+03	9.01E+03	3.23E+03

Table 3. (continued).

Component	V-1	V-2	V-3	V-9	Average[a]
Manganese (Mn)	7.02E+02	2.23E+03	1.15E+03	4.27E+03	1.50E+03
Mercury (Hg)	2.05E+02	1.16E+02	1.85E+02	1.67E+03	2.59E+02
Nickel (Ni)	8.14E+01	7.60E+01	8.52E+01	3.19E+02	9.54E+01
Phosphorous (P)	9.63E+03	1.34E+04	1.50E+04	4.04E+04	1.45E+04
Silicon (Si)	2.10E+04	2.23E+04	2.19E+04	7.07E+04	2.46E+04
Silver (Ag)	3.52E+01	5.05E+01	2.49E+01	5.22E+02	6.39E+01
Zinc (Zn)	4.46E+03	4.17E+02	1.34E+03	1.41E+03	1.98E+03
VOCs					
PCE	4.38E+02	1.38E+02	1.30E+02	4.25E+02	2.37E+02
TCA	3.14E-01	1.56E-01	1.59E-01	1.77E+03	1.05E+02
TCE	3.85E+00	3.62E-01	2.95E-01	1.45E+04	8.54E+02
SVOCs					
BEHP	9.19E+02	5.86E+02	1.21E+03	3.45E+02	9.10E+02
Aroclor-1260	3.46E+01	2.44E+01	3.58E+01	9.59E+01	3.59E+01
Radionuclides					
Cs-137 (nCi/g)	1.74E+03	1.81E+03	1.88E+03	4.48E+03	1.98E+03
Sr-90 (nCi/g)	1.52E+03	3.20E+03	5.36E+03	5.18E+03	3.68E+03
TRU (nCi/g)	1.10E+01	4.02E+00	7.29E+00	2.64E+01	8.57E+00
Other					
Total Carbon[c]	1.67E+04	3.33E+04	2.85E+04	9.19E+03	2.53E+04

a. Average concentrations are calculated using a weighted average based on tank mass.

b. Does not include chlorides from organics.

c. Assumed to be organic carbon.

The following overarching assumptions will be used for the treatment alternatives:

- The ICDF will be available to accept the V-tank waste by 2003.
- Design and treatment operations will be performed to meet "clean closure" requirements.
- ATG will remain a nonviable alternative for treatment of the V-tank waste. No other off-Site treatment will be available prior to 2005.
- Nevada Test Site (NTS) or Hanford will be accepting out-of-state mixed wastes for treatment/disposal by 2007.

- TAN-616 will be removed down to its foundation by the time remediation is initiated.
- Buildings surrounding Technical Support Facility (TSF)-09 and TSF-18[a] (other than TAN-616) will not be affected by the remedial action and removal of TAN-616.
- The Waste Isolation Pilot Plant (WIPP) will not be accepting remote-handled waste by the estimated completion time for treatment of V-tank waste (2005).
- Sufficient data exist from previous treatability studies on V-tank waste (simulated or actual) or comparable waste streams, such that additional treatability studies are not required for the technology selection.
- The contents of Tank V-9 can be slurried and removed without additional liquid.
- V-tank waste is considered a single waste stream for the purpose of establishing treatment requirements.
- The V-tank waste is assumed to be characteristically hazardous, which invokes the full list of underlying hazardous constituents. Therefore, for example, PCBs require treatment to the LDR limit of 10 ppm and BEHP requires treatment to the LDR limit of 28 ppm for disposal of the primary waste form at ICDF.
- Maximum achievable control technology (MACT) emissions standards apply to both of the VIT alternatives and to the TD on-Site alternative.
- The sample data, as reported and summarized in Table 3, are accurate and represent the constituents of the V-tanks.
- Equipment for transferring the slurried V-tank sludge and liquid phases will require temporary shielding and secondary containment. Equipment decanting V-tank liquid, prior to slurrying, requires only secondary containment.
- A total of 6,000 gallons of liquid will be removed from Tank V-3 using a decanting system before initiating this operation (as part of Early Remedial Actions).
- Contamination control during excavation of contaminated soil is a significant concern, but it can be managed by maintaining slightly damp soil conditions, placing wind restriction on operation, temporary tarps, etc., as opposed to large temporary containment structures.
- All equipment coming in contact with the waste or its residuals during processing may have to be disposed of at the ICDF as debris. However, an effort should be made to recover or reuse as much of this equipment as possible before disposing of it as debris waste.
- For comparison of the various alternatives, secondary waste volumes expressed in this report will be based on no size reduction of equipment or debris.
- For comparison of the various alternatives, all filters are assumed to be debris subject to macroencapsulation if found to be hazardous or not conforming to waste acceptance criteria. This includes high efficiency particulate air (HEPA) filters and granulated activated carbon (GAC)

a. Tanks V-1, V-2, and V-3 have an OU 1-10 CERCLA Site identifier of Technical Support Facility (TSF)-09, while Tank V-9 has the identifier of TSF-18.

filters. This assumption is used for secondary waste disposal and cost estimates. In reality, if the GAC material is in particulate form and removable from the absorption vessel, the assumption of macroencapsulation may not be correct.

2.2 Technical and Functional Requirements

An overarching set of general TFRs was developed applicable to all of the alternatives for processing V-tank waste. The following bullets present these preliminary TFRs with the understanding that detailed design will define a more comprehensive list. The primary waste form refers to the final, treated form of the bulk V-tank solids (for VIT and TD) and the combined solids and liquids for CO/S.

2.2.1 Overarching TFRs

- Components of the treatment system shall have real-time monitoring capability (pressure, flow, etc.).
- The treatment system shall be capable of using existing tank accesses (20-in. manhole, risers, etc.) for either tank waste transfer or in situ treatment, unless specifically identified otherwise.
- The treatment system shall be capable of operation with available electrical power sources at TAN or a suitable portable generator will be provided.
- Components of the treatment system shall have microprocessor or PC control capability for process variables (e.g., temperature, pressure, environmental controls).
- The treatment system shall have process data collection and storage capability.
- The treatment system shall produce a final primary waste form that meets the ICDF or other designated Treatment, Storage, and Disposal Facility (TSDF) waste acceptance criteria.
- The treatment system shall be capable of batch operations.
- The treatment system shall be capable of direct or remote operation, as required. Ex situ alternatives will require significantly greater use of specialized materials handling, shielding, and containment.
- The treatment system shall have secondary containment where required.
- All systems shall be leak tested prior to use.
- Process streams shall be compatible with the existing V-tanks or new treatment system components for the maximum estimated duration of the operation.
- Operating personnel and the environment shall be protected against industrial and radiological hazards.
- Suitable on-Site interim storage shall be provided for primary and secondary waste prior to further treatment or disposal.

2.2.2 Waste Transfer Subsystem TFRs

The waste transfer subsystem shall be capable of:

- Sediment phase removal using minimal additional uncontaminated water, thus, resulting in a remaining quantity of residual heel low enough to allow the tank to be qualified as "empty"
- Slurrying the settled sediment phase with the residual supernatant phase, such that both phases are homogenized
- Being back-flushed to the originating tank
- Real-time monitoring (pressure, flow, etc.).

2.2.3 Applicable or Relevant and Appropriate Requirements (ARARs)

The following ARARs are taken from the ROD (DOE-ID 1999a). These are only used as guidance to evaluate the alternatives, and are not binding at this time. The Technology Evaluation Report (DOE/ID 2002a) provides a listing of proposed ARARs specific to the preferred alternative. These ARARs are:

- Rules for the control of air pollutants in Idaho:
  - "Toxic Substances" (IDAPA 16.01.01.161)
  - "Toxic Air Emissions" (IDAPA 16.01.01.585 and .586)
  - "Fugitive Dust" (IDAPA 16.01.01.650 and .651)
  - "Requirements for Portable Equipment" (IDAPA 16.01.01.500.02)
- National Emission Standards for Hazardous Air Pollutants (NESHAP)
  - "Radionuclide Emissions from DOE Facilities" (40 CFR 61.92)
  - "Emission Monitoring" (40 CFR 61.93)
  - "Emission Compliance" (40 CFR 61.94(a))
- RCRA – Standards Applicable to Generators of Hazardous Waste
  - "Hazardous Waste Determination" (40 CFR 262.11)
  - "Manifest" (40 CFR 262, Subpart B)
  - "Pre-Transportation Requirements" (40 CFR 262.30–262.33)
- RCRA – Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Units
  - "General Waste Analysis" (40 CFR 264.13[a][1-3])
  - "Security of Site" (40 CFR 264.14)
  - "General Inspections" (40 CFR 264.15)
  - "Personnel Training" (40 CFR 264.16)
  - "Preparedness and Prevention" (40 CFR 264, Subpart C)

- "Contingency Plan and Emergency Procedures" (40 CFR 264, Subpart D)
- "Equipment Decontamination" (40 CFR 264.114)
- "Use and Management of Containers" (40 CFR 264.171-178)
- "Tank Closure and Post-Closure Care" (40 CFR 264.197[a])

- RCRA – Land Disposal Restrictions
  - "Land Disposal Restriction (LDR) Treatment Standards" (40 CFR 268.40[a][b][e])
  - "Treatment Standards Expressed as Specified Technologies" (40 CFR 268.42[a][b][c])
  - "Universal Treatment Standards" (40 CFR 268.48[a])
- CERCLA – Disposal Requirements
  - "CERCLA Off-Site Policy" (40 CFR 300.440)
- Radiation Protection of the Public and the Environment
  - DOE Order 5400.5, Chapter II (1)(a, b)
- Institutional Controls
  - Region 10 Final Policy on the Use of Institutional Controls at Federal Facilities.